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India's technology opportunity: Transforming work, empowering people

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India in 2025: potential impact of 12 empowering technologies

$550–1,000 billion
annual economic impact (20–30% of India's incremental GDP from 2012 to 2025)

400 million
additional people with access to quality health care

300 million
financially included people

14–24 million
workers could gain more years of education

15–60%
yield improvement for 22 million farmers due to precision agriculture

$50–95 billion
savings and productivity gain from energy technologies

$17–25 billion
economic value from intelligent transportation (roads and ports)

10 million
tech-enabled workers in health care, education, agriculture, citizen services, and financial services

19–29 million
non-farm workers who will need new job opportunities and skills

Executive summary

India has made progress towards its goal of bringing millions of people out of extreme poverty. However, despite these efforts, some 680 million Indians, or 56 percent of the population, still lack the basics of a minimum acceptable standard of living. What India needs now is a productivity- and efficiency-led transformation. If India can raise the productivity of its labour force and deliver basic services 50 to 100 percent more efficiently than in the past decade, half a billion people in India can be lifted to what we call the MGI "Empowerment Line", where they have the capacity to meet basic needs and maintain a decent standard of living, with access to health care, education, and other vital services.[1]

In this report we focus on a set of powerful technologies that can help raise productivity, improve efficiency across major sectors of the economy, and radically alter how services such as education and health care are delivered. By themselves—or even in combination—these technologies cannot bring about the full transformation that India needs. But these 12 technologies can have a disruptive impact on Indian businesses, government, and society. These "empowering" technologies have the potential to add economic value of $550 billion to $1 trillion per year in 2025, create millions of well-paying productive jobs (including ones for people with moderate levels of formal education), and help bring a decent standard of living to millions of Indians. Among our key findings:

- India is likely to experience very rapid diffusion and adoption of 12 general-purpose technologies and technology applications in the coming decade. The most potent of these, the mobile Internet, will likely reach 700 million to 900 million Indians by 2025. Along with cloud-based services, the automation of knowledge work, digital payments, and verifiable digital identity, the mobile Internet can provide the foundation for remote health care, adaptive learning, mobile agricultural extension services, and other innovative services. Beyond digital technologies, rapid advancements in energy (unconventional oil and gas, renewables, storage), genomics, advanced geographic information systems (GIS), and intelligent transportation and distribution can help India build a more stable power supply, raise productivity in farming, move goods and people more efficiently, and improve access to clean drinking water.

- When technology-based applications are used in combination, they can have transformative effects. For example, the mobile Internet could bring the knowledge of specialist physicians to community health workers using a combination of two other disruptive technologies: "automation of knowledge work" software residing in the cloud. Another powerful combination is using Internet of Things technology (tiny sensors that can be used for tracking),

1 For a detailed discussion on the Empowerment Line and the basket of basic consumption needs required for a minimum acceptable standard of living, see *From poverty to empowerment: India's imperative for jobs, growth, and effective basic services*, McKinsey Global Institute, February 2014.

the mobile Internet, and the cloud to monitor prescription drugs and stanch the flow of counterfeits. Internet of Things sensors in the water-supply infrastructure sending readings across the mobile Internet can detect flaws that could lead to contamination and consequent illness. No single technology application is as transformative as these combinations.

- Collectively, the 12 empowering technologies for India could contribute $550 billion to $1 trillion of economic impact per year in India in 2025. This is an estimate of the value created by additional productivity, savings of time and cost and energy, as well as benefits that these technologies could generate such as lives prolonged, carbon emissions avoided, and workers educated. The estimated impact is based on an analysis of more than 40 high-impact technology applications across seven sectors of the economy: financial services, education, health care, agriculture, energy, infrastructure, and government services.

- Much of the value created by empowering technologies likely will flow to consumers, including those in the poorer segments of the population. This "consumer surplus" would arise in a number of ways, including time savings, lower costs, greater convenience, and improved health. We estimate that empowering technologies can help some 400 million poor rural Indians gain access to improved health-care services (via remote health care and technology-enabled community health workers) and 24 million students gain four to eight more years of additional education by 2025. India's people can also benefit from technology in government that can boost transparency, curb corruption, and make government programmes more effective, for example, by using mobile payments to reduce leakage in welfare benefits.

- Our broad estimates suggest that 19 million to 29 million workers (5 to 8 percent of India's non-farm labour force in 2025) could potentially be negatively affected by technology and would need new employment opportunities and skills training. Some 6 million to 8 million of these workers would be employed in routine clerical, customer service, and sales jobs that could be affected by advancements in machine learning and natural language interfaces (speech recognition) that make it possible for computers to take on work that had been thought to be beyond machines. An additional 13 million to 21 million jobs in manufacturing, trade, transport, and construction could be affected by technology applications. To create a workforce that can adapt to such shifts, India will need a radical overhaul of education and vocational training systems as well as investments in continuous learning.

- Opportunities will likely be created for millions of workers and entrepreneurs by empowering technologies. Up to 20 million small and medium-sized enterprises (SMEs) could gain access to digital business tools in the cloud at a fraction of the cost of running in-house information technology (IT). About 90 million farmers could raise their productivity with real-time market information and as many as 22 million through precision farming. Millions of workers with little formal education could become knowledge workers in community health care, education, banking, and agriculture. With a bit of training and equipped with tablet computers linked to powerful cloud-based knowledge applications, they could make rudimentary diagnoses, teach lessons, provide farm-extension services, or help illiterate Indians conduct financial transactions.

- Ubiquitous digital technology can help create a "nation of micro-entrepreneurs". The mobile Internet and the cloud make it possible for all sorts of small service providers—caregivers, food preparers, plumbers, and drivers, as well as financial planners, accountants, and other freelance professionals—to find customers and offer services in an online marketplace. Consumers would benefit from an explosion of choices, and talented suppliers could build strong local or national reputations. Indians can also use this type of platform to participate in the "sharing economy"—matching real-time demand with spare or underutilised capacity. Consumers could connect to share rides for daily commutes, rent a car, or arrange a last-minute place to stay. Online sharing has many business applications, too—locating spare office space, meeting rooms, or even manufacturing or storage capacity or unused delivery vans.

- Disruptive technologies also involve disruptive business models, which can undermine the advantages of incumbents. Traditional sources of strategic advantage, such as established brands, large networks of stores or branches, and even factories could become balance sheet liabilities in a world of digital commerce and virtual organisations. A new source of competitive advantage will likely be the ability to drive greater consumer surplus using disruptive technologies. Business processes will become increasingly data-driven, and the most valuable asset may be talent with superior skills in data analytics. In an extreme scenario, the core business of a bank in 2025 could become one of branding and risk management, with most traditional banking elements outsourced to technology utilities.

- Government plays a key role in enabling (or holding back) new technologies and applications. The explosive growth of mobile phone service, which is having an impact on economic growth, in India was accelerated by early government measures to liberalise the telecommunications market and pro-consumer policies that reduced costs. Similarly, the government can accelerate the build-out of the telecom infrastructure needed to bring the mobile Internet to rural areas, and support domestic manufacturing of the low-cost devices needed in the digital economy. To promote adoption of empowering technologies, the government can also encourage entrepreneurism and innovation. Recent policy announcements suggest this has become a priority for the government. Its Digital India initiative, announced in August 2014, emphasises that digital infrastructure (digital identity, mobile Internet, electronic bank accounts) should become a widespread utility for citizens. It also envisions access to cloud-enabled services on demand and cashless financial transactions. Previously the government had announced a Rs. 10,000 crore ($1.7 billion) fund for startups, a Rs. 7,000 crore ($1.2 billion) budget to fund smart cities projects, and Rs. 500 crore ($90 million) for the National Rural Internet and Technology Mission.

IDENTIFYING 12 TECHNOLOGIES THAT WILL MATTER TO INDIA

To identify empowering technologies for India, we start with the criteria used to select MGI's global disruptive dozen: a disruptive technology has to have the potential for rapid adoption within a set time frame (by 2025); its benefits and impact must be felt widely, affecting many people, institutions, products, and markets; and the technology must have significant economic impact.[2] For India, we apply a fourth criterion: the technology must have the potential to help address India's economic and social challenges.

The resulting list of 12 empowering technologies for India fall into three types: technologies that "digitise" life and work, smart physical systems, and technologies for rethinking energy (Exhibit E1). Our list includes four technologies that are not on the global list, but which have particular relevance in India: digital payments, verifiable digital identity, intelligent transportation and distribution, and advanced GIS. All the technologies on our list are likely to reach rapid adoption in the coming decade (Exhibit E2). A few other technologies—advanced robotics, autonomous vehicles, 3D printing, and advanced materials—are also potentially important for India, but we do not focus on them in this research.

Exhibit E1

Twelve technologies can empower India in the next decade

Digitising life and work	**Mobile Internet**	Inexpensive and increasingly capable mobile devices and Internet connectivity enable services to reach individuals and enterprises anywhere
	Cloud technology	Computing capacity, storage, and applications delivered as a service over a network or the Internet, often at substantially lower cost
	Automation of knowledge work	Intelligent software for unstructured analysis, capable of language interpretation and judgment-based tasks; potential to improve decision quality
	Digital payments	Widely accepted and reliable electronic payment systems that can bring millions of unbanked Indians out of the cash economy
	Verifiable digital identity	Digital identity that can be verified using simple methods, enabling secure delivery of payments and access to government services
Smart physical systems	**Internet of Things**	Networks of low-cost sensors and actuators to manage machines and objects, using continuous data collection and analysis
	Intelligent transportation and distribution	Digital services, used in conjunction with the Internet of Things, to increase efficiency and safety of transportation and distribution systems
	Advanced geographic information systems (GIS)	Systems that combine location data with other types of data to manage resources and physical activities across geographic spaces
	Next-generation genomics	Fast, low-cost gene sequencing and advanced genetic technologies to improve agricultural productivity, nutrition, and health care
Rethinking energy	**Advanced oil and gas exploration and recovery**	Techniques that make extraction of unconventional oil and gas (usually from shale) economical, potentially improving India's energy security
	Renewable energy	Generation of electricity from renewable sources to reduce harmful climate impact and bring power to remote areas not connected to the grid
	Advanced energy storage	Devices or systems for energy storage and management that reduce power outages, variability in supply, and distribution losses

SOURCE: McKinsey Global Institute analysis

2 *Disruptive technologies: Advances that will transform life, business, and the global economy*, McKinsey Global Institute, May 2013.

Exhibit E2

Potential adoption of 12 empowering technologies in India

	Metric	Current estimates	Realistic aspiration for 2025
Mobile internet	Mobile Internet penetration in India	~8–10%	50–60%
	Mobile Internet users in India	100–130 million	700–900 million
Cloud technology	Percent of SMEs with a Web presence	<10%	50–55%
	Number of SMEs that are potential cloud users	~2 million	~20 million
	Extent of cloud-based government services to citizens	Nascent	Virtually universal
Automation of knowledge work	Number of smartphone users (potential intelligent app users)	~60 million	700–900 million
	Nature of applications	Basic, such as online information and booking	Adaptive, across sectors such as agriculture, health, education
Digital payments	Number of retail electronic and card transactions per year	1.5 billion	12 billion
	Number of retail establishments accepting digital payments (% of total)	0.6 million (6%)	>6 million (>60%)
Verifiable digital identity	Share of India's population with Aadhaar unique identity	~50%	~100%
	Share of financial and non-financial transactions linked to verifiable digital identity	<1%	~100% for all transactions needing identity verification
Internet of Things	Number of connected devices globally	9 billion	>50 billion
	Potential number of connected devices in India	n/a	2–10 billion
Intelligent transportation and distribution	Penetration of smart grid technology in India	<1% of grid	60–80% of grid
	Number of cities in India with some form of smart transport	<5	At least 50 (all current Tier 1 and Tier 2 cities)
Advanced geographic information systems (GIS)	Scope of GIS assets in India	Basic satellite images of forests, ground-water, soil, minerals from multiple agencies	Integrated, up-to-date, easy-to-use maps overlaid with diverse geo-tagged data including 3D, under-ground, and crowdsourced data
	GIS-based applications in India	Used by a few state governments; few apps for citizens	Ubiquitous GIS apps for decision support by all segments
Next-generation genomics	Hectares under hybrid and genetically modified crops in India (% of total planted area)	18 million ha (9%)	40 million ha (20%)
	Medical therapies based on advanced genomics	Nascent	Personalised therapies for 0.5–1.5 million patients; prenatal screening of 5–10 million births
Advanced oil and gas exploration and recovery	Unconventional gas production	~10 billion cubic feet	~235 billion cubic feet
Renewable energy	Solar energy generating capacity (in gigawatts)	1.7 GW	43 GW
	% of total generating capacity from solar	0.7%	9%
Advanced energy storage	Storage cost per megawatt-hours of energy	~$300	~$80
	Storage applications	Only large users	Universal use

SOURCE: Internet and Mobile Association of India; Pyramid Research; MGI SME survey on Internet usage; Reserve Bank of India; Unique Identification Authority of India; Cisco; Planning Commission, Government of India; International Service for the Acquisition of Agri-biotech Applications; Ministry of Agriculture, Government of India; World Health Organization; McKinsey Global Institute analysis

POTENTIAL ECONOMIC IMPACT OF $550 BILLION TO $1 TRILLION IN 2025

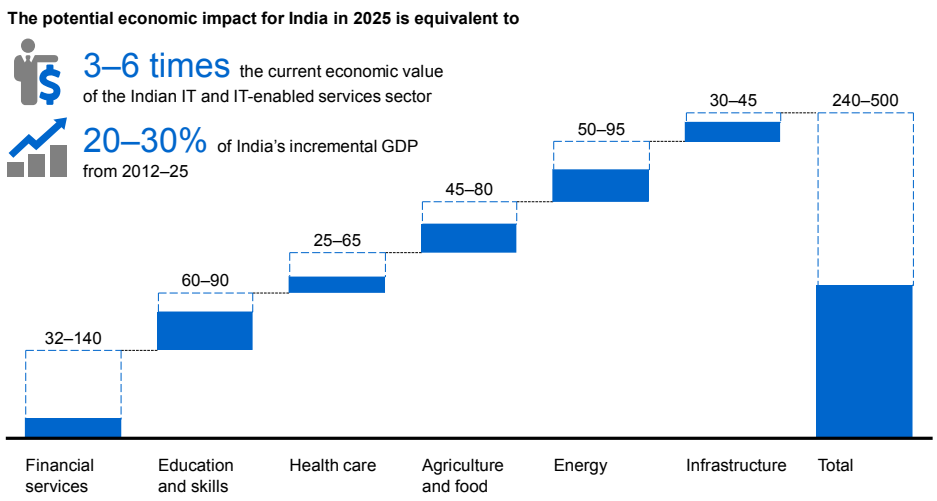
The 12 empowering technologies for India have the potential to create both economic and social value and can help India achieve its goals of rapid economic growth, greater social inclusion, and better governance by 2025. We estimate a potential economic impact of $550 billion to $1 trillion per year in 2025, led by applications in finance, energy, and education (Exhibit E3). This would be equivalent to 20 to 30 percent of India's GDP growth between 2012 and 2025, or three to six times the direct economic value contributed by the entire information technology sector in 2012. To understand the economic impact, we analyse a select set of applications across seven sectors: financial services, education, health care, agriculture, energy, infrastructure, and government services. The economic impact of these sized applications in 2025 could be $250 billion to $500 billion, or about 45 percent of the total impact.[3]

Exhibit E3

Economic impact of empowering technologies could be $550 billion to $1 trillion in 2025, with $240 billion to $500 billion from sized applications

Potential economic impact in 2025

Sized applications in six sectors ($ billion)



Notes on sizing

- Estimates of economic impact are not comprehensive and include potential direct impact of sized applications only.
- These estimates do not represent GDP or market size (revenue), but rather economic potential, including consumer surplus. Comparisons with GDP are only illustrative of the potential scope of impact.
- These estimates are not achievable through technology alone. They assume that enablers, such as training, incentives, and infrastructure, are put in place to capture the full potential value.
- Relative sizes of impact shown here cannot be considered a "ranking" because sizing is not comprehensive.
- We do not quantify the split or transfer of surplus among or across companies or consumers. Such transfers would depend on future competitive dynamics and business models.
- Estimates are not directly additive due to partially overlapping applications and/or value drivers.
- The estimates are not fully risk- or probability-adjusted.

NOTE: Numbers may not sum due to rounding.
SOURCE: McKinsey Global Institute analysis

3 We do not size the economic impact of government services separately.

Beyond their economic impact, these technologies can help transform the lives of millions of Indians. By our estimates, they can help 200 million to 250 million Indians improve nutrition and raise incomes by receiving their full entitlements of subsidised food (using electronic payments or technology-enabled distribution to reduce leakage of benefits). About 90 million farmers in 2025 could improve their incomes through access to real-time market information. Technology-based teaching methods can improve school learning outcomes and thereby raise the productivity of some 24 million students who will enter the workforce by 2025, and help bring vocational training to 18 million to 33 million more Indians. An estimated 300 million Indians could achieve financial inclusion through technology-enabled services in 2025, and 400 million of India's poor could gain access to improved health-care services.

Realising this potential will not only require overcoming barriers such as limited telecom infrastructure, but it will also involve risks and costs that will need to be weighed. Widespread use of digital technologies raises questions about privacy and intellectual property protections. Businesses and individuals can be exposed to cybercrime. Advances in energy and genomics have implications for the environment. Regulators and policy makers will need to inform themselves about these issues, engage with the public and the business community, weigh the risks, and make their own judgments about necessary safeguards.

HOW 12 TECHNOLOGIES CREATE VALUE IN INDIA

To assess the potential contribution of empowering technologies to India's future, we conducted a bottom-up analysis of applications in seven sectors of the Indian economy that account for 45 percent of GDP and more than 60 percent of employment. In each of these sectors, we identify key challenges and the technologies that can help address them. For each sector, we rely on case examples and expert insights to refine the analysis and identify barriers to adoption and possible interventions.

- **Financial services.** India's banking sector has used technology to digitise business operations and to create new delivery models and services, such as online brokerage, mobile banking, and online insurance sales. Disruptive technologies now offer an opportunity to address persistent challenges such as lack of financial inclusion; just 36 percent of Indians have access to a bank account. Technology applications such as mobile payments can bring greater efficiencies; the government pays some $100 billion per year through paper-based channels. The applications we size could translate into economic value of $32 billion to $140 billion per year in 2025. The value arises from improved productivity and higher incomes of those using the services, and lower costs and reduced leakage in government transfers and payments. As many as 300 million Indians could gain access to banking services and could raise their incomes by 5 to 30 percent due to better access to credit and the ability to save and make remittances. Leakage of subsidies could be reduced by 8 to 10 percent.

- **Education and skills.** Learning outcomes in India's educational institutions are poor due to variable quality of teaching, and vocational training capacity is not adequate for the growing workforce. If these issues are not addressed, India could have far too many low-skill workers in 2025 than the labour market will require. Technology applications can improve the quality of teaching and raise vocational attainment. School performance can be improved through e-administration, digital identity-based attendance systems, and online teacher certification and training. Blended learning with MOOCs (massive open online courses) can bring high-quality courses to students, and learning simulations can boost hands-on training in nursing and other disciplines. We estimate an economic impact of $60 billion to $90 billion per year by 2025 from the higher productivity of more skilled workers. India could have about 24 million more high school- and college-educated workers and 18 million to 33 million more vocationally trained workers by 2025 due to use of digital technologies in the education sector.

- **Health care.** Based on international standards, India has about half the doctors, nurses, and health-care centres it needs for its population, and existing facilities are not geared to delivering optimal health outcomes. Disruptive technologies could transform delivery of public health services by 2025, extending care through remote health services (delivering expert consultations via the mobile Internet), digital tools that enable health-care workers with modest skills to carry out basic protocols, and low-cost diagnostic devices that work with smartphones. Using Internet of Things tracking systems to curb counterfeit drugs could be worth as much as $15 billion per year. The total value of empowering technologies in health care could be $25 billion to $65 billion per year in 2025. Of this, the largest share ($15 billion to $30 billion) could come from equipping health-care centres and health workers to bring services to some 400 million of India's poor.

- **Agriculture and food.** India's agriculture sector has made strides since the Green Revolution but still has immense potential to raise farm productivity and farm income. Hybrid and genetically modified crops, precision farming (using sensors and GIS-based soil, weather, and water data to guide farming decisions), and mobile Internet-based farm extension and market information services can help create more than half the $45 billion to $80 billion per year in additional value the sector could realise in 2025. The remainder would come from improvements to storage and distribution systems, which could cut postharvest losses and reforms to the public distribution system to reduce leakage, together saving as much as $32 million per year in 2025. These improvements could raise the income of as many as 100 million farmers and bring better nutrition to 300 million to 400 million consumers.

- **Energy.** Under current trends, by 2025, India could become one of the most energy-insecure countries in the world. Energy inclusion is also a major challenge: some 300 million people lack access to electricity. Globally disruptive energy technologies will have tremendous potential to improve sources of power in India as well: unconventional oil and gas, solar technology, and both grid and off-grid and offshore renewable energy sources like wind, solar, and seaweed biofuels. Advanced metering infrastructure, low-cost energy storage devices, and energy utilisation technologies can capture efficiencies along the value chain. Collectively, the technology applications we size in energy could have economic impact of $50 billion to $95 billion per year in 2025, including the impact of carbon emissions avoided. The largest potential impact would come from smart metering, which could save India $15 billion to $20 billion per year in 2025 in reduced transmission losses. Other large contributors would be energy-efficiency technologies for buildings and vehicles, which could save $15 billion worth of energy, and unconventional oil and gas, which might generate value of $10 billion per year in 2025.

- **Infrastructure.** India has a widely acknowledged infrastructure deficit that successive governments have attempted to address. Overcrowded roads, aging rail lines, and port systems using antiquated technology all slow the flow of goods and people and limit the growth potential of the economy; in India, logistics represent 14 percent of the cost of goods, compared with 6 to 8 percent globally. India needs new water and sanitation systems and has a housing gap of more than 18 million units. Infrastructure projects frequently come in late, over budget, and short of specifications. Use of radio frequency identification (RFID) tags and other tracking technologies can automate terminal and warehouse management, raising efficiency by 50 percent. Using sensors, water systems can cut leakage by 15 to 20 percent, helping reduce water shortages. And project-management systems and next-generation building technologies (extensive use of factory-made prefabricated parts, for example) can help India deliver ten million affordable homes by 2025. Together these infrastructure technologies can contribute $30 billion to $45 billion per year in value in 2025.

- **Government services.** Like other nations, India grapples with the challenge of making its government more effective and responsive to citizens. By our estimate, 50 percent of government spending on basic services does not translate into real benefits for people, and cumbersome government processes are an obstacle to investment and growth. We do not size the economic impact of e-government services, but their positive impact on competitiveness is well established. India has made a good start with its National e-Governance Plan, and it can take additional steps to capture the full potential over the next decade. Reengineering core government processes to simplify them and providing more integration of multiple services on technology platforms are essential next steps.

HOW TO NOURISH EMPOWERING TECHNOLOGIES

For these technologies to take root and have the level of impact we describe, India needs to create a supportive environment. In this report, we highlight a few broad-based enablers that the government could put in place to ensure that the benefits of empowering technologies can be felt across India.

- **Building physical infrastructure for the digital economy.** The cloud, the mobile Internet, the Internet of Things, digital payments, and other digital technologies depend on an affordable, reliable, and far-reaching Internet infrastructure. Universal, affordable Internet access is becoming a basic amenity of modern life and can be facilitated by fair and non-discriminatory regulatory policies. Accelerating implementation of the government's optical fibre backbone project will be critical in bringing Internet service to more citizens. There is also need to open up more spectrum for the massive growth in wireless data traffic. Cloud service providers need low-cost facilities with reliable electricity and access to telecom facilities.

- **Addressing barriers to technology adoption.** Lack of digital literacy is a significant barrier in India, and addressing this is essential to raise adoption rates for empowering technologies. India's many languages complicate the task of making technology accessible, as does the high rate of illiteracy. One approach may be to make systems as intuitive as the games and entertainment content that are so popular with smartphone users. Workers in government and private-sector organisations may also need to raise their technology skills to adopt advanced digital systems. Few companies or ministries have the in-house talent to conceptualise and create new applications and processes using digital systems. Setting up special-purpose government-sponsored technical organisations focused on training and capacity building for specific areas can help.

- **Providing effective policies, regulations, and standards.** For technologies to flourish in India, companies and consumers need a clear and predictable legal and regulatory environment. Policy approaches should be technology-agnostic and flexible; they should allow application and content developers to innovate with clear protections for copyrights and other intellectual property as well as data ownership. Citizens need protections to guard privacy and prevent cybercrime. In energy and genomics, best-practice regulatory frameworks address possible environmental, health, and security risks. Common standards for interoperability of data and devices can help expand the size of the market and encourage greater innovation. Finally, government can facilitate use of technologies in combinations (such as combining advanced GIS data with crop and soil data, and using advanced data analytics to provide advice to farmers via agricultural extension workers using the mobile Internet). This will require collaboration among many players: the Department of Space captures GIS images, and the Ministries of Planning, Agriculture, and Water collate data on soil conditions, water supplies, and other economic and natural resources, while farm extension workers are employed by the states.

- **Creating a vibrant innovation ecosystem and a mindset of "going for scale".** India can follow global best practices for creating a better environment for innovation. For example, Colombia created a one-stop shop and a central business registration database, reducing the average time needed to set up a new business from 57 days to three days. Apart from an overall business-friendly environment, startups can benefit from having a collection of well-defined problem statements, grand challenges, and idea pipelines. The Mahindra Spark the Rise challenge and Techpedia's online repository of 140,000 university technology projects are examples. As in the case of India's mobile telephony sector, scaling up for massive impact requires more than technology; large-scale innovation requires new approaches to pricing, manufacturing, and distribution, which can be facilitated by the right regulatory environment. Government procurement can also be used as a way to scale up new technologies. The government's Rs. 10,000 crore ($1.7 billion) fund for startups could be used to support promising technologies through purchases by ministries where appropriate.

- **Fostering more openness and transparency in government.** Open data can enable all sorts of applications, innovations, and new business models. India launched a government open data portal in 2013 that now provides access to more than 7,900 data sets. More departments and agencies could open up their data through a combination of mandates, incentives, and education to encourage more sharing. Timely and useful content sharing from the government also builds user engagement for online services. Indonesia launched the Public Participation Information System, which allowed citizens to monitor and verify the delivery of government services in real time, via a website or using SMS texting. The data can be used to improve resource allocation, for example to quickly fund the rebuilding of a fallen bridge. System data can also identify which mobile phone users who have registered with the site are close enough to investigate the problem and check whether it has been fixed.

- **Attracting private-sector R&D investment.** Research and development spending in India, at just 0.87 percent of GDP, is significantly lower than in Brazil (1.19 percent), China (1.70 percent), the United Kingdom (1.87 percent), the United States (2.79 percent), and South Korea (3.36 percent). India can attract more R&D investment and resources from global corporations and the domestic private sector. To do this, India would need to open its markets, remove barriers to doing business, and improve intellectual property protections. The government could consider establishing a dedicated public-private development fund for core technologies in infrastructure, energy, biotechnology, advanced genomics, and other high-priority fields. The government can also help fill some gaps in know-how by supporting a dedicated agency to work with the private sector to build expertise in areas such as data analytics and by establishing centres of excellence in solar R&D and renewable-energy management through public-private partnerships.

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Empowering technologies can make a significant contribution to India's economic growth and its efforts to reduce poverty and enable more people to achieve a decent lifestyle, with greater economic opportunities and better access to water, sanitation, education, and health care. At the same time, powerful technological change carries risks for which India needs to prepare; millions of workers whose jobs include tasks that smart systems can perform might need to acquire new skills. The technologies we focus on in this research potentially will transform how Indians work, live, educate their children, travel, and engage with their government in the coming decade. They are only part of the solution to India's challenges; wider reforms and investments are also needed. But adopting these technologies can equip the nation to meet its larger challenges and help unleash the productivity- and efficiency-led transformation that India needs.

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